



PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Serial No.: 10/535,311

Confirmation No. 5735

In re Application of:

Group Art Unit: 4174

Masakazu Funahashi et al.

Examiner: NELSON, MICHAEL

Filed: May 18, 2005

For: Organic electroluminescence element

DECLARATION UNDER 37 CFR 1.132

I, Masakazu FUNAHASHI, declare that:

1. I received a master degree from Tokyo Institute of Technology graduate school in March, 1993. I have been employed since April, 1993 by IDEMITSU KOSAN CO., LTD. of 6-1, Yokoami 1-chome, Sumida-ku, Tokyo 130-0015 Japan, and have been engaged in research on molecular design and synthesis of organic electroluminescent materials, in the Central Research Laboratory of that company from June, 1993. I have personal knowledge of the facts stated herein, except for these facts which are based on information and belief.

2. All statements made herein based on my own knowledge are true and all statements made on information and belief are believed to be true.

3. Experiment was conducted to establish the patentability of the claimed invention. An object of the experiment is to show that the light-emitting-layer material and second dopant need to satisfy (B) $EC0 \geq EC2$ in order to obtain desired advantages of the present invention. An object of the experiment is to show that the light-emitting-layer material, first dopant and second dopant need to satisfy (C) $EG0 > EG1$ and $EG0 > EG2$ in order to obtain desired advantages of the present invention.

4. Experiment

In each experiment, the properties of compounds used and organic EL elements produced were evaluated in the following ways.

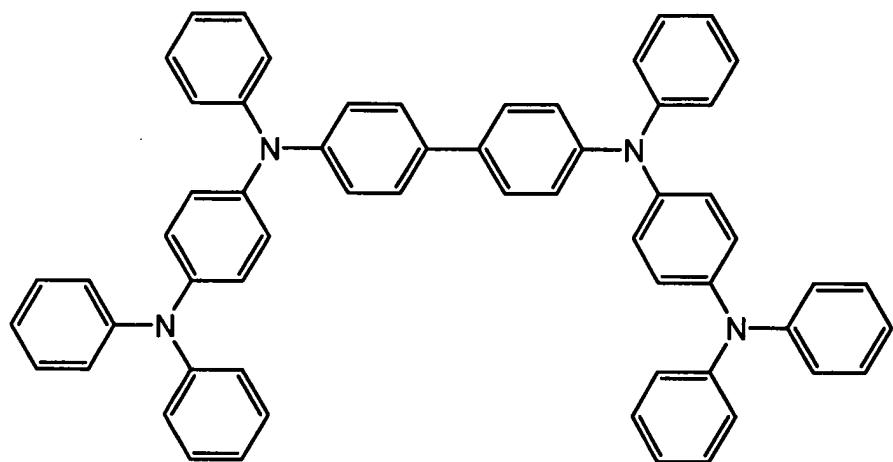
- (1) Valence electron level: It was measured with a photo-electron spectroscopic instrument (AC-1, Riken Keiki Co., LTD) in air. Specifically, light was irradiated to a material and the amount of electrons generated by charge separation was measured.
- (2) Energy gap: It was measured based on an absorption edge of an absorption spectrum in benzene. Specifically, an absorption spectrum was measured with a commercially available ultraviolet-visible spectrophotometer. The energy gap was calculated from the wavelength in which the spectrum begins to raise.
- (3) Conduction level: It was calculated from the measured values of a valence electron level and an energy gap.
- (4) Luminance: It was measured with a spectro radio luminance meter (CS-1000, MINOLTA Co., Ltd.).
- (5) Efficiency: It was calculated from a current density and a luminance (100 nit) measured with a multimeter.
- (6) Half life: For an element sealed, it was measured at room temperature at 1000 nit of an initial luminance and constant current.

The formulas of compounds used in the experiments are shown

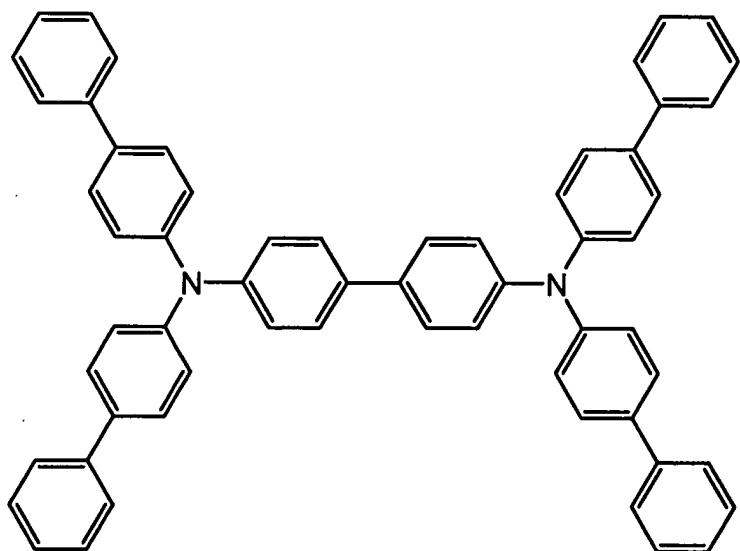
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below.

The valence electron levels, conduction levels and energy gaps of these compounds are shown to Table I.

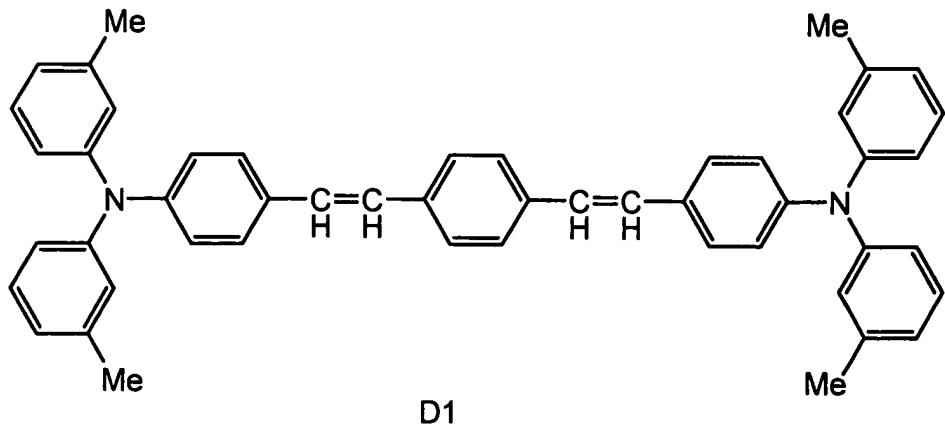


TPD232

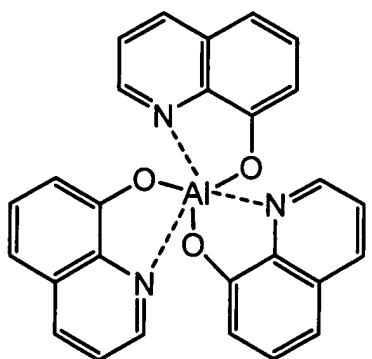


TBDB

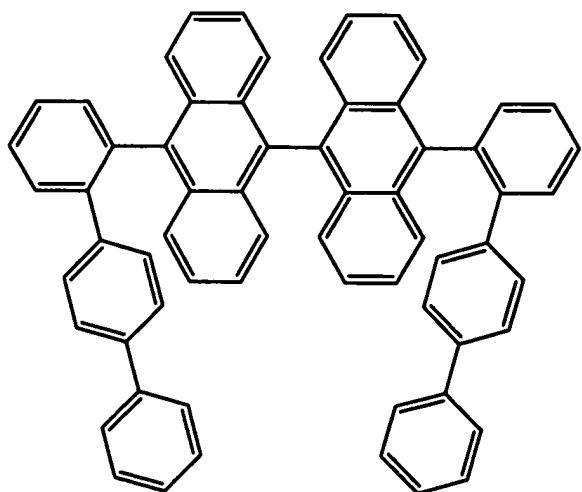
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D1

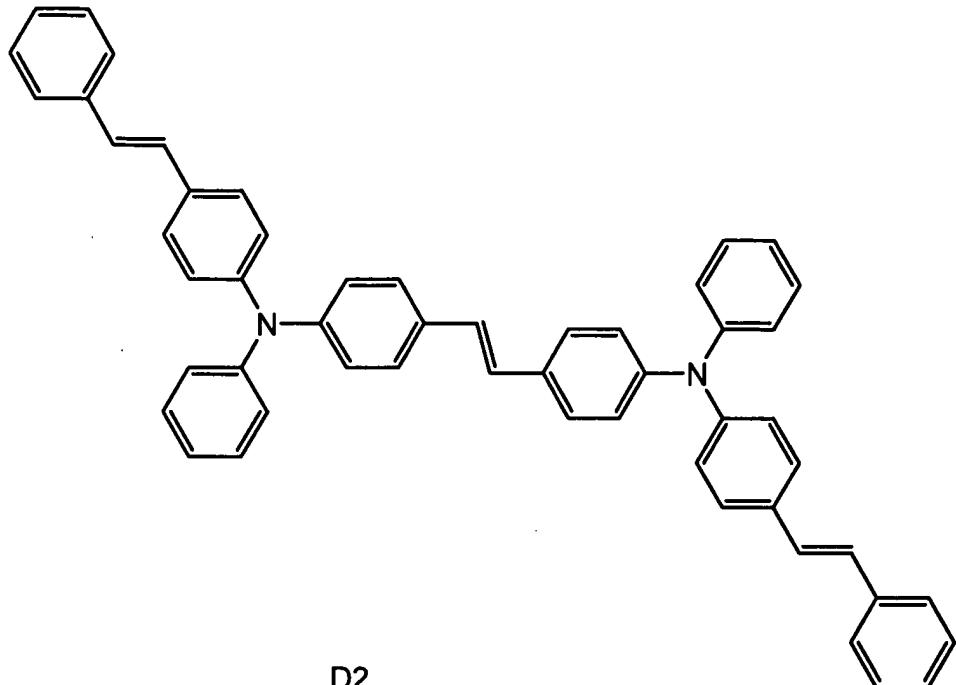


Alq

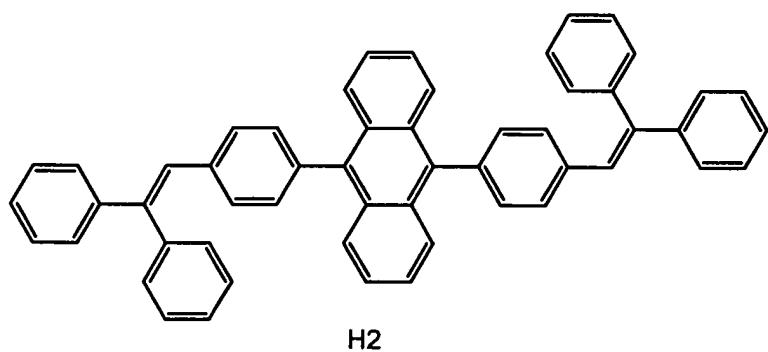


H1

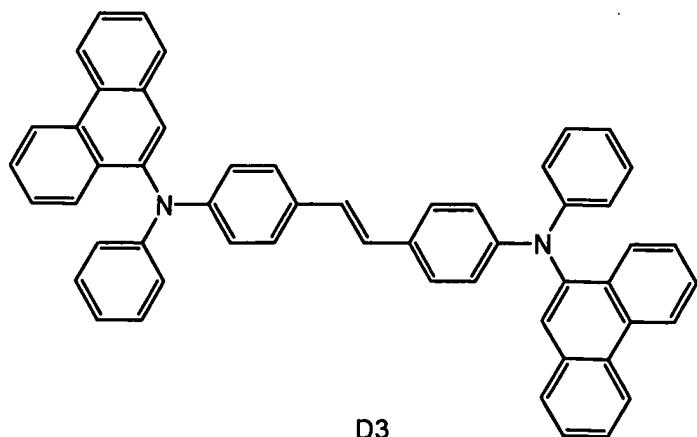
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D2

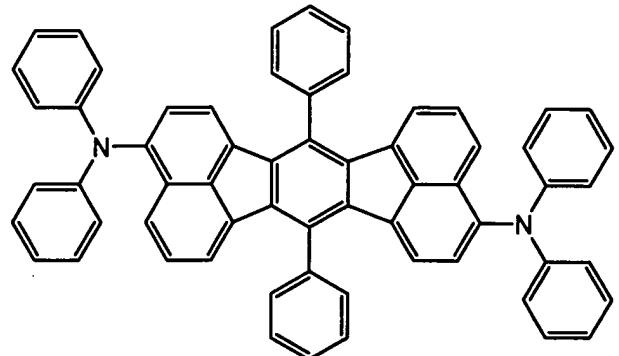


H2

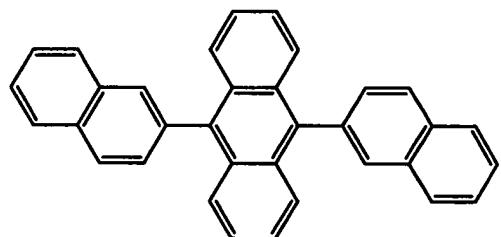


D3

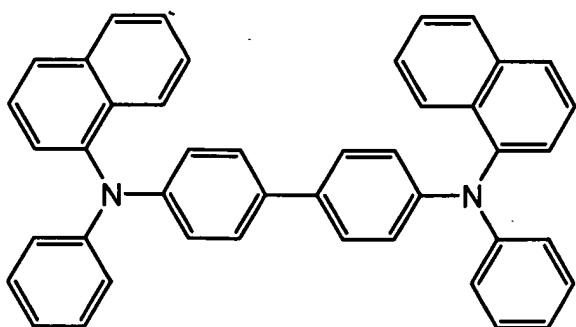
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D4

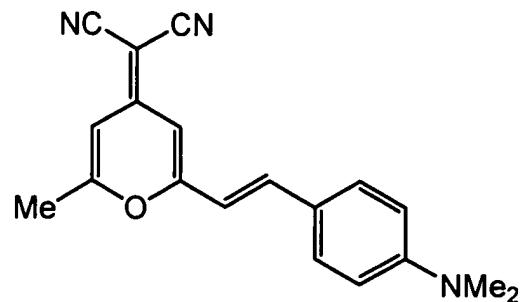


H3

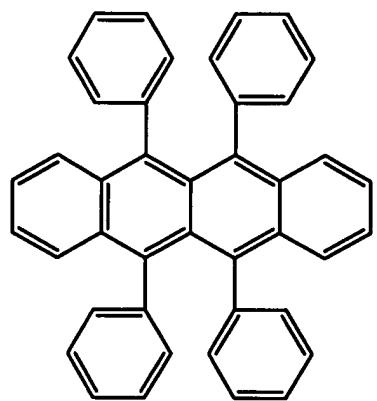


NPB

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D5



D6

Table I

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Compound	Valence electron level (EC)	Conduction Level (EC)	Energy Gap (EC)
H1	5.7	2.7	3.0
H2	5.7	2.8	2.9
H3	5.7	2.7	3.0
D1	5.5	2.7	2.8
D2	5.4	2.6	2.8
D3	5.4	2.5	2.9
D4	5.6	3.0	2.6
D5	5.2	3.1	2.1
D6	5.3	3.1	2.2
NPB	5.4	2.3	3.1

Experiment A

A glass substrate of 25 mm by 75 mm by 1.1 mm with an ITO transparency electrode (GEOMATEC CO., LTD.) was subjected to ultrasonic cleaning with isopropyl alcohol for 5 minutes, and cleaned with ultraviolet rays and ozone for 30 minutes.

The resultant substrate was mounted on a substrate holder in a vacuum deposition device. First, a film of N,N'-bis(N,N'-diphenyl-4-aminophenyl)-N,N'-diphenyl-4,4'-diamino-1,1'-biphenyl (TPD232 film), having a film thickness of 60 nm, was formed so as to cover the surface of the transparency electrode on which transparency electrode lines were formed. The TPD232 film functioned as a hole injecting layer.

After forming the TPD232 film, a layer of N,N,N',N'-tetra(4-biphenyl)-diaminobiphenylene (TBDB layer), having a film thickness of 20 nm, was formed on the TPD232 film. The film functioned as a hole transporting layer.

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Thereafter H1 as a light-emitting-layer material, D1 as a first dopant and D2 as a second dopant were deposited to form a 40nm-thick film such that D1:D2:H1 (weight ratio) was 1:1:40. The film functions as a light emitting layer.

Next, an Alq film with a film thickness of 10 nm was formed on the film. The Alq film functions as an electron injecting layer.

Thereafter Alq and lithium as a reductive dopant (lithium source: Saesgetter Co., Ltd.) were co-deposited to form an Alq:Li film (film thickness of 10nm) as an electron injecting layer (cathode).

Metal aluminum was deposited on this Alq:Li film to form a metallic cathode, thereby forming an organic EL element.

Experiment B

An organic EL element was produced in the same way as in Experiment A except that D5 was used instead of D1.

Experiment C

An organic EL element was produced in the same way as in Experiment A except that NPB was used instead of D2.

Experiment D

An organic EL element was produced in the same way as in Experiment A except that D5 was used instead of D1, and D6 was used instead of D2.

Experiment E

An organic EL element was produced in the same way as in Experiment A except that D5 was used instead of D1, and NPB was used instead of D2.

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In the organic EL elements produced in Experiments A to E, light-emitting-layer materials used; and each kind, valence electron level and conduction level of the first dopants and the second dopants used are shown in Table II.

Table II

	Light emitting layer material		First dopant		Second dopant	
Experiment A	H1	EV0:5.7 EC0:2.7 Eg0:3.0	D1	EV1:5.5 EC1:2.7 Eg1:2.8	D2	EV2:5.4 EC2:2.6 Eg2:2.8
Experiment B	H1	EV0:5.7 EC0:2.7 Eg0:3.0	D5	EV1:5.2 EC1:3.1 Eg1:2.1	D2	EV2:5.4 EC2:2.6 Eg2:2.8
Experiment C	H1	EV0:5.7 EC0:2.7 Eg0:3.0	D1	EV1:5.5 EC1:2.7 Eg1:2.8	NPB	EV2:5.4 EC2:2.3 Eg2:3.1
Experiment D	H1	EV0:5.7 EC0:2.7 Eg0:3.0	D5	EV1:5.2 EC1:3.1 Eg1:2.1	D6	EV2:5.3 EC2:3.1 Eg2:2.2
Experiment E	H1	EV0:5.7 EC0:2.7 Eg0:3.0	D5	EV1:5.2 EC1:3.1 Eg1:2.1	NPB	EV2:5.4 EC2:2.3 Eg2:3.1

Experimental result

The organic EL elements produced in Experiments A to E, were evaluated for a luminescent efficiency at a luminance near 100 nit, and a half life at 1000 nit of an initial luminance. Evaluation results were shown in Table III.

Table III

	Driving voltage (V) @100nit	Luminous efficiency (cd·A) @100 nit	Half life (h) @1000 nit	Color of emitted light
Experiment A	5.0	12.3	15,000	blue
Experiment C	5.2	12.0	7,000	
Experiment B	7.2	7.1	8,000	orange
Experiment D	8.0	6.4	3,000	
Experiment E	7.7	6.2	5,000	

When Experiment B and Experiment D are compared, Experiment B and Experiment D are different only in second dopant contained in the emitting layer. The emitting layer of Experiment D does not satisfy (B) among (A) to (C) of the present invention, while the emitting layer of Experiment B satisfies all of (A) to (C) of the present invention (Table II). As a result, the organic EL element of Experiment D is inferior to all of the driving voltage, luminous efficiency and half life in comparison with Experiment B (Table III).

That is to say, this shows the light-emitting-layer material and second dopant need to satisfy $EC0 \geq EC2$ in order to obtain desired advantages of the present invention.

When Experiment A and Experiment C, and Experiment B and Experiment E are compared, Experiment A and Experiment C are different only in second dopant contained in the emitting layer, and Experiment B and Experiment E also are different only in second dopant contained in the emitting layer. The emitting layer of Experiment C and Experiment E does not satisfy (C) among (A) to (C) of the present invention, while the emitting layer of Experiment A and Experiment

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B satisfies all of (A) to (C) of the present invention (Table II).

As a result, the organic EL element of Experiments C and E is inferior to all of the driving voltage, luminescent efficiency and half life in comparison with Experiments A and B (Table III).

That is to say, this shows the light-emitting-layer material, first dopant and second dopant need to satisfy (C) $EG_0 > EG_1$ and $EG_0 > EG_2$ in order to obtain desired advantages of the present invention.

I declare under penalty of perjury under the laws of the United States that the foregoing is true and correct. I acknowledge that willful false statements and the like are punishable by fine or imprisonment, or both and may jeopardize the validity of the application or any patent issuing thereon.

Date: March 13 2008

Masakazu Funahashi
MASAKAZU FUNAHASHI